

CLAIMS

1. A method of analysing results from an electromagnetic survey of an area that is thought or known to contain a subterranean hydrocarbon reservoir, comprising:
 - 5 providing a first survey data set obtained from a vertical electric dipole (VED) source;
 - providing a second survey data set obtained from a vertical magnetic dipole (VMD) source;
 - generating a first normalisation data set specific to the first survey data set;
 - 10 generating a second normalisation data set specific to the second survey data set;
 - combining the first survey data set and first normalisation data set to obtain a first results data set that represents a difference between the first survey data set and the first normalisation data set;
 - 15 combining the second survey data set and second normalisation data set to obtain a second results data set that represents a difference between the second survey data set and the second normalisation data set; and
 - comparing the first and second results data sets to determine if hydrocarbon is present.
- 20 2. A method of analysing results from an electromagnetic survey of an area that is thought or known to contain a subterranean hydrocarbon reservoir, comprising:
 - providing a first survey data set obtained from a vertical electric dipole (VED) source;
 - 25 providing a second survey data set obtained from naturally occurring magnetotelluric (MT) electromagnetic fields;
 - generating a first normalisation data set specific to the first survey data set;
 - generating a second normalisation data set specific to the second survey data set;

combining the first survey data set and first normalisation data set to obtain a first results data set that represents a difference between the first survey data set and the first normalisation data set;

combining the second survey data set and second normalisation data set to
5 obtain a second results data set that represents a difference between the second survey data set and the second normalisation data set; and

comparing the first and second results data sets to determine if hydrocarbon is present.

10 3. A method of analysing results from an electromagnetic survey according to claim 1 or 2, further comprising:

normalising each of the first and second survey data sets relative to the respective first and second normalisation data sets or first and second functions specific to the first and second data sets respectively.

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4. A method of analysing results from an electromagnetic survey according to any one of claims 1 to 3, wherein the first and second normalisation data sets or functions are calculated from a rock formation model.

20 5. A method of analysing results from an electromagnetic survey according to any one of claims 1 to 3, wherein the first and second normalisation data sets or functions are calculated from the first and second survey data sets.

6. A method of analysing results from an electromagnetic survey according to
25 any one of claims 1 to 4, wherein the first results data set represents the difference between the first survey data set and the first normalisation data set as a function of position within the area, and the analysis of the first results data set includes identifying a location of a boundary of the subterranean hydrocarbon reservoir.

7. A computer program product bearing machine readable instructions for implementing a method of analysing results from an electromagnetic survey according to any one of claims 1 to 6.
- 5 8. A computer apparatus loaded with machine readable instructions for implementing the method of analysing results from an electromagnetic survey according to any one of claims 1 to 6.
9. An electromagnetic survey method for surveying an area that is thought or
10 known to contain a subterranean hydrocarbon reservoir, comprising:
obtaining a first survey data set from a vertical electric dipole (VED) source;
obtaining a second survey data set from a vertical magnetic dipole (VMD)
source; and
analysing the first and second survey data sets according to the method of
15 claim 1 or any one of claims 3 to 6 when dependent on claim 1.
10. An electromagnetic survey method according to claim 9, wherein the VED source and the VMD source are mounted on a common submersible vehicle.
- 20 11. An electromagnetic survey method according to claim 9 or 10, wherein the first and second survey data sets are obtained together.
12. An electromagnetic survey method according to claim 9 or 10, wherein the first and second survey data sets are obtained separately.
- 25 13. An electromagnetic survey method according to any one of claims 9 to 12, wherein the VED and VMD sources are operated at different frequencies.

14. An electromagnetic survey method for surveying an area that is thought or known to contain a subterranean hydrocarbon reservoir, comprising:
obtaining a first survey data set from a vertical electric dipole (VED) source;
obtaining a second survey data set from naturally occurring magnetotelluric
5 (MT) electromagnetic fields; and
analysing the first and second survey data sets according to the method of claim 2.
15. A method of planning an electromagnetic survey of an area that is thought or
10 known to contain a subterranean hydrocarbon reservoir, comprising:
creating a model of the area to be surveyed including a seafloor, a rock formation containing a postulated hydrocarbon reservoir beneath the seafloor, and a body of water above the seafloor;
setting values for water depth, depth below the seafloor of the postulated
15 hydrocarbon reservoir, and resistivity structure of the rock formation;
performing a simulation of an electromagnetic survey in the model of the survey area by obtaining a first survey data set from a simulated vertical electric (VED) dipole source and a second survey data set from a simulated vertical magnetic dipole (VMD) source; and
20 analysing the first and second survey data sets according to the method of claim 1 or any one of claims 3 to 6 when dependent on claim 1.
16. A method of planning an electromagnetic survey of an area that is thought or known to contain a subterranean hydrocarbon reservoir, comprising:
25 creating a model of the area to be surveyed including a seafloor, a rock formation containing a postulated hydrocarbon reservoir beneath the seafloor, and a body of water above the seafloor;
setting values for water depth, depth below the seafloor of the postulated hydrocarbon reservoir, and resistivity structure of the rock formation;

performing a simulation of an electromagnetic survey in the model of the survey area by obtaining a first survey data set from a simulated vertical electric (VED) dipole source and a second survey data set from simulated magnetotelluric (MT) electromagnetic fields; and

- 5 analysing the first and second survey data sets according to the method of claim 2.

17. A method of planning an electromagnetic survey according to any one of claims 15 or 16, further comprising:

- 10 repeating the simulation for a number of source-to-detector distances and frequencies in order to select optimum surveying conditions in terms of source-to-detector distance for probing the hydrocarbon reservoir.

18. A method of planning an electromagnetic survey according to any one of
15 claims 15 to 17, wherein the model includes a body of air above the body of water, and wherein the simulation takes account of signal propagation paths including the body of air when calculating the first and second survey data sets.

19. A method of planning an electromagnetic survey according to any one of
20 claims 15 to 17, further comprising:

 normalising each of the first and second survey data sets relative to respective first and second normalisation data sets or functions specific to the first and second survey data sets respectively.

25 20. A computer program product bearing machine readable instructions for implementing the method of planning an electromagnetic survey according to any one of claims 15 to 19.

21. A computer apparatus loaded with machine readable instructions for implementing the method of planning an electromagnetic survey according to any one of claims 15 to 19.
- 5 22. A submersible vehicle for subsea electromagnetic surveying, comprising:
a vertical electric dipole (VED) source; and
a vertical magnetic dipole (VMD) source.
- 10 23. A submersible vehicle according to claim 2², wherein the VED source and the VMD source comprise respective antennae mounted such that their dipole axes are aligned.
- 15 24. A submersible vehicle according to claim 22 or 23, further comprising at least one waveform generator operable to transform a high voltage, low current AC drive signal received from an umbilical cable into a low voltage, high current AC drive signal to drive the VMD and VED antennae.
- 20 25. A survey apparatus comprising:
a submersible vehicle according to any one of claims 22 to 24;
a signal power supply unit for generating a high voltage, low current signal power supply for the submersible vehicle; and
an umbilical cable releasably connectable at ends thereof to the signal power supply unit and the submersible vehicle.
- 25 26. A survey apparatus according to claim 25, further comprising a plurality of electromagnetic signal detectors.
27. A surface vessel carrying a survey apparatus according to claim 25 or 26.

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28. A static platform carrying a survey apparatus according to claim 25 or 26.
29. A well carrying a survey apparatus according to claim 25 or 26.
- 5 30. A borehole carrying a survey apparatus according to claim 25 or 26.